MINERALS IN THE HUMAN BODY
Crystal chemistry of cement-asbestos†

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ABSTRACT

A study of a representative number of cement-asbestos (CA) samples removed from different localities in Italy has been accomplished with a combination of analytical techniques, including XRF, XRPD, SEM/EDS, micro-Raman, and electron backscattered diffraction (EBSD), to elucidate the mineralogical and chemical variability of this class of building materials on a large scale. We describe a complex mineralogy including phases of cement hydration, residual non-hydrated components, and a relevant fraction attributed to various processes of deterioration. With the aid of the CaO-MgO-SiO2 compositional diagram, three groups of CAs have been identified on the basis of their chemical parameters. This result is important for environmental and waste management issues.

Keywords: Cement-asbestos, Rietveld method, CaO-MgO-SiO2, carbonation, SEM, EBSD

INTRODUCTION

Cement-asbestos (CA) are undoubtedly the most common form of asbestos-containing materials (ACMs) produced worldwide. According to recent estimates for Italy, one of the European countries where ACMs were extensively used in the past, ~2 billion m2 of cement-asbestos slates still cover roofs of industrial and civil buildings (D’Orsi 2007). Their widespread distribution is obviously a matter of great concern as it has been long recognized that CA in open environment undergoes physical-chemical degradation which eventually leads to the release of breathable fibers (Babic 2006; Dias et al. 2008; Spurny et al. 1989). Motivated by human health concerns, a substantial effort was devoted to the detection and potential dispersion of asbestos minerals from ACM (Burdett 2007; Sarkar et al. 1987; Spurny et al. 1989). Since CA are the first fiber reinforced cement composites of modern times, the degradation of their mechanical properties with time have been extensively studied (Bentur and Mindess 2007), whereas their chemical and mineralogical characterization raised less scientific interest and has usually been limited to the study of few samples (Dias et al. 2008; Laviano et al. 2002).

The chemical and mineralogical variability of CA at a large scale is directly connected with the so-called asbestos problem. In Europe, the ban of asbestos, following specific European directives prompted the problem of safe disposal and/or inertization of ACM. Since then, several industrial processes for thermal transformation of CAs have been proposed (Abruzzese et al. 1998; Borderes 2000; Downey and Timmons 2005; Leonelli et al. 2006; Gualtieri et al. 2006a); their economic sustainability bears also on the perspective of recycling opportunities for thermally transformed ACMs. In principle, batches of CA materials from different plants, in particular slates, undergoing the same thermal treatment may yield different end products. In Italy, before the ban of ACMs in 1992, production of CA was carried out in many geographically distinct plants, employing different processes and raw materials (Fazzo et al. 2012). A preliminary survey, conducted on a limited area of Southern Italy (Laviano et al. 2002) evidenced a strong dependence on the production plant of chemical composition as well as mineralogical assemblage of roof slates.

Most of CA products have been manufactured through the Hatschek process and its modifications, in which a very dilute slurry of asbestos fibers (up to about 10–15 wt% of solids) and ordinary Portland cement (OPC) was gradually dried, obtaining films of about 0.3 mm thickness, which in turn were wound up on a roll to a desired thickness, and finally shaped (Bentur and Mindess 2007). Curing of green CA might be accelerated by increasing temperature and/or pressure in the autoclave. During this process, a single layer formation is a critical step in which asbestos fibers play a crucial role. The final product can be roughly described as a cement composite material in which asbestos minerals were employed as reinforcing agent, thanks to the high-tensile strength.